

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>C07F 9/00, 11/00, 7/00, 19/00, C08F 4/64</b>		<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 97/45434</b>
			<b>(43) International Publication Date:</b> 4 December 1997 (04.12.97)
<b>(21) International Application Number:</b> PCT/FI97/00321			<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
<b>(22) International Filing Date:</b> 27 May 1997 (27.05.97)			
<b>(30) Priority Data:</b> 962292 31 May 1996 (31.05.96) FI			
<b>(71) Applicant (for all designated States except US):</b> BOREALIS A/S [DK/DK]; Lyngby Hovedgade 96, DK-2800 Lyngby (DK).			
<b>(72) Inventors; and</b>			
<b>(75) Inventors/Applicants (for US only):</b> POLAMO, Mika [FI/FI]; Wärtsiläkatu 16 A 19, FIN-04400 Järvenpää (FI). LESKELÄ, Markku [FI/FI]; Rauduntie 19D, FIN-02130 Espoo (FI). HAKALA, Kimmo [FI/FI]; Itälahdenkatu 5 B 22, FIN-00210 Helsinki (FI). LÖFGREN, Barbro [FI/FI]; Niittyranta 17B, FIN-00930 Helsinki (FI).			
<b>(74) Agent:</b> NESTE OY; Patent Services, P.O. Box 310, FIN-06101 Porvoo (FI).			<b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> NOVEL TRANSITION METAL COMPLEXES AND METHOD FOR PREPARING THEM			
<b>(57) Abstract</b> <p>A transition metal complex having a general formula of <math>M(RNpy)_yX_z</math> where M is a transition metal selected from groups IVb-VIb of The Periodic Chart of the Elements, RNpy is unsubstituted or substituted amidopyridine derivative, X is a ligand having a valency of 1, y is 1-4, z is 0-5 and y+z is 3-6. This complex can be used for polymerization of olefins together with acceptor compound, such as methylalumoxane.</p>			

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

Novel transition metal complexes and method for preparing them

5 The present invention deals with new complexes of transition metals and a method for preparing them. The invention concerns also a catalyst system of transition metal complexes for polymerizing ethylenically unsaturated monomers. Further the invention concerns a method for homo or copolymerizing ethylenically unsaturated monomers in the presence of a catalyst system comprising a transition metal complex and an organometallic  
10 compound.

Olefin polymerization with Ziegler-Natta catalysts has been used for a long time. These catalysts are based on complex systems of organoaluminium compounds and at least one transition metal compound, especially titanium. Ziegler-Natta catalysts are very sensitive to  
15 catalyst poisons, especially for oxygen and water. The structure of the real catalyst is at least partly still unknown. Based on the wide molecular weight distribution of the produced polymers, it has been proposed that the traditional Z-N catalysts contain several, structurally different active sites (see G. Fink, R. Mülhaupt and H.H. Brintzinger, editors in Ziegler-Catalysts, Springer-Verlag, Berlin Heidelberg, 1995).

20

Recently catalysts based on metallocene compounds and alumoxane compounds have been developed. In these catalysts a transition metal atom, normally zirconium, hafnium or titanium is sandwiched between parallel planar cyclopentadienyl groups. The activity of metallocenes is greatly improved by stabilizing with a bulky non-coordinating MAO anion.

25 Operating in the presence of these catalysts polymers having a narrow molecular weight distribution with improved yield can be obtained. Metallocene catalysts are extremely active. They are structurally well characterized and typical for them is that they contain a single active center which results in very homogenous polymer. This can be seen as narrow molecular weight distribution. (see M. Bochmann, J. Chem. Soc. Dalton. Trans.,  
30 1996,225).

European patent application 0687693 discloses amidinato complexes, which have allylically connected resonance structures and perform high molecular weight distribution with moderate activity in olefin polymerization.

- 5 The purpose of the present invention is to find new alternative complex systems, which are more active in the polymerization or copolymerization of olefins and other monomers than conventional Ziegler-Natta catalysts. The new complexes also have advantages of metallocenes, especially single active site. The purpose of the invention is also a transition metal complex which can be prepared by a method which is very easy and economical.
- 10 Still another purpose of the invention is a catalyst system comprising a novel transition metal complex and an activator compound for polymerization of ethylenically unsaturated monomers, especially  $\alpha$ -olefins.

According to the present invention it has been found that amidopyridine ligands offer an  
15 electronically and sterically rigid structure with heterocyclic  $\pi$ -donor and amido bond without coordination of conjugated double bonds seen in the known metallocene complexes and amidinato complexes according to EP687693. The complexes according to the invention differ significantly from the previously patented ones both structurally and in catalytic performance producing polymers with a very narrow molecular weight  
20 distribution and good activity.

The transition metal complex according to the invention is characterized in that it has a general formula (I)



where

M is a transition metal selected from groups IVb-VIb of The Periodic Chart of the Elements,

30

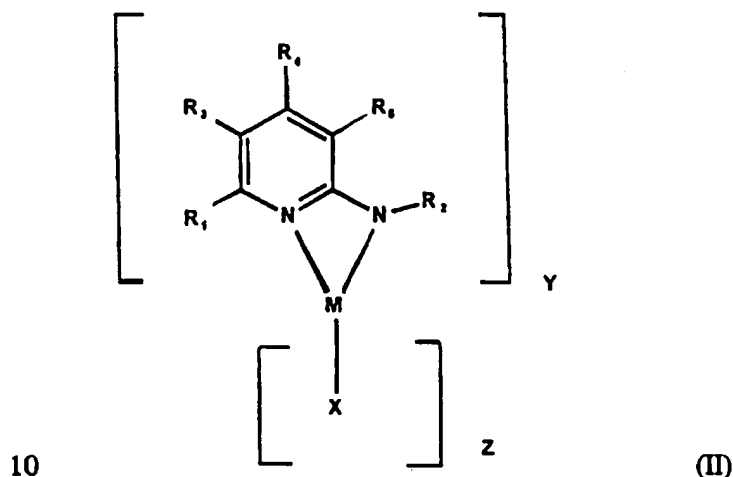
RNpy is unsubstituted or substituted amidopyridine derivative,

X is a ligand having a valency of 1, and

y is 1-4, z is 0-5 and y+z is 3-6.

5 Transition metal M can be selected from Ti, Zr, Hf, V, Nb, Ta, Cr, Mo or W.

The complexes of the present invention can be presented also by a general formula of (II):



where

15  $R_2$  is selected from hydrogen or linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group or cyclic  $C_1$ - $C_7$  alkylene group connected to groups  $R_1$ ,  $R_3$ ,  $R_4$ , or  $R_5$  as defined below, or silyl alkyl  $SiRR'R''$  or boron alkyl  $BRR'$  where R, R' and R'' are as defined for  $R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$ ,

20  $R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$  are same or different groups selected from hydrogen, linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group, or a cyclic  $C_1$ - $C_7$  alkylene group connected to  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ , or  $R_5$ , or substituted main group element (B, C, Si, N, O, P, As, Sb, Pb..) with a substituent as  $R_1$ - $R_5$ ,

M is a transition metal selected from Ti, Zr, Hf, V, Nb, Ta, Mo, Cr or W,

X groups are independently halide and/or oxo group or alkyl as  $R_2$ , or  $-NRR'$  where R and R' are as  $R_2$ , and X can also act as a bridge between two or more  $M(RNpy)_yX_{z-1}$  units, and

5

y is 1-4 and z is 0-5 and  $y+z$  is 3-6.

Preferably X is halide, such as chloride, bromide, iodine or fluoride, or methyl or ethyl group. In the the case of V, Mo, W it can be an oxo group.

10

Typical examples of compounds according to formula (I) are the following compounds, where Py = pyridine (pyridyl), Bz = benzyl and Ph = feryl:

2-(phenylamino)pyridiniumtetrachloro-2-(phenylamido)pyridine titanate(IV)  
15  $[PhNHPyH][TiCl_4(PhNPy)]$ ,

di- $\mu$ -chlorodichlorotetrakis[2-(phenylamido)pyridine]dizirconium(IV)  
 $[Zr_2Cl_4(PhNPy)_4]$ ,

20 tetrakis[2-(phenylamido)pyridine]hafnium(IV)  
 $[Hf(PhNPy)_4]$ ,

trichlorobis[2-(phenylamidopyridine)]niobium(V)  
 $[NbCl_3(PhNPy)_2]$ ,

25

bis[2-(benzylamido)pyridine]trichloroniobium(V)  
 $[NbCl_3(PyNBz)_2]$ ,

trichlorobis[2-(phenylamido)pyridine]tantalum(V)  
30  $[TaCl_3(PhNPy)_2]$ ,

trichlorobis(2-phenylamido-6-phenylaminopyridine-N,N')tantalum(V)



bis[2-(benzylamido)-4-methylpyridine]trichlorotantalum(V)

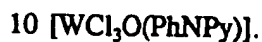


5

bis[2-(benzylamido)-4-methylpyridine]trichlorotantalum(V)



trichloro-2-(phenylamido)pyridineoxotungsten(VI)



The invention concerns also a method for preparing the complexes above, which is characterized in that 2-(phenylamido)pyridine or 2-(benzylamido)pyridine is reacted with a halide or halide derivative of a transition metal selected from groups IVb-VIb. Preferably the transition metal is selected from Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, or W. The halide is selected from chloride, bromide, iodine or fluoride, preferably chloride.

According to a preferable embodiment of the invention the catalyst complexes are prepared by using 2-(phenylamido)pyridine, 2-(benzylamido)pyridine or their derivatives, and halides of transition metals as starting materials. In the preparation method solvents can be used or not used. In the first mentioned case 2-(phenylamido)pyridine is dissolved in a proper solvent. The solution can be cooled down to  $-70\text{ }^{\circ}\text{C}$  -  $0\text{ }^{\circ}\text{C}$  before contacting with halide. Alternatively the solution can be carried out at room temperature or at higher temperature.

25

The reaction between the amidopyridine and transition metal halide can be carried out at a temperature between  $50\text{-}150\text{ }^{\circ}\text{C}$  or refluxing at the boiling temperature of the solvent. The reaction time can vary from 10 min to 10 hours, preferably 1-3 h.

30 As solvents typical aromatic solvents like toluene, benzene or xylene can be used.

The starting materials can be contacted also without solvents by melting them together. The temperature can in this case vary between 50 °C and 200 °C, preferably however 0-10 °C above the melting point of the aminopyridine ligand used. The reaction time is not critical and it can vary between 10 min to 10 hours, preferably between 1 to 3 hours.

5

During the reaction HCl (gas) or ligand-HCl adducts are developed. These can be removed by extracting with a proper solvent, such as toluene. The catalyst complexes of the invention can be obtained in conventional way, for example by crystallization methods.

10 The invention concerns also a catalyst system for homo or copolymerizing ethylenically unsaturated monomers. The catalyst system according to the invention is characterized in that it comprises

A) a transition metal complex having a general formula (I)

15



where

M is a transition metal selected from groups IVb-VIb of The Periodic Chart of the  
20 Elements,

RNPy is unsubstituted or substituted amidopyridine derivative,

X is a ligand having a valency of 1, and

25

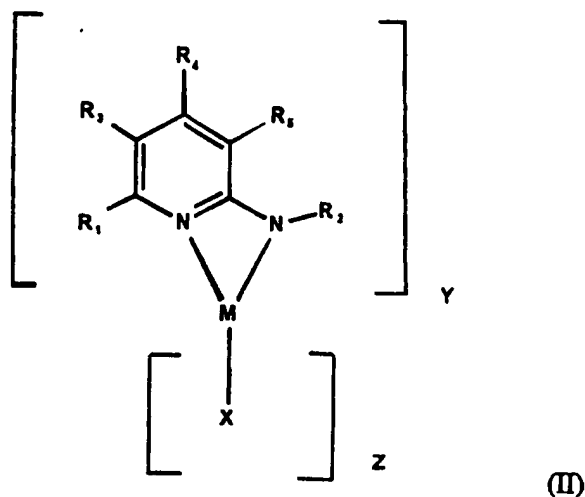
y is 1-4, z is 0-5 and y+z is 3-6, and

(B) an acceptor compound for component X as an activator.

30 Transition metal M can be selected from Ti, Zr, Hf, V, Nb, Ta, Cr, Mo or W.

The component (A) can be presented also by a general formula (II)





where

5

$R_2$  is selected from hydrogen or linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group or cyclic  $C_1$ - $C_7$  alkylene group connected to groups  $R_1$ ,  $R_3$ ,  $R_4$  or  $R_5$  as defined below, or silyl alkyl  $SiRR'R''$  or boron alkyl  $BRR'$  where  $R$ ,  $R'$  and  $R''$  are as defined for  $R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$ .

10  $R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$  are same or different groups selected from hydrogen, linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group, or a cyclic  $C_1$ - $C_7$  alkylene group connected to  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  or  $R_5$ , or substituted main group element (B, C, Si, N, O, P, As, Sb, Pb..) with a substituent as  $R_1$ - $R_5$ .

15  $M$  is a transition metal selected from Ti, Zr, Hf, V, Nb, Ta, Cr, Mo, or W,

$X$  groups are independently halide and/or oxo group or alkyl as  $R_2$ , or  $-NRR'$  where  $R$  and  $R'$  are as  $R_2$ , and  $X$  can also act as a bridge between two or more  $M(RNpy)_yX_{z-1}$  units, and-

20  $y$  is 1-4 and  $z$  is 0-5 and  $y+z$  is 3-6.

Preferably  $X$  is halide, such as chloride, bromide, iodine or fluoride, or methyl or ethyl group. In the the case of V, Mo, W it can be an oxo group.

The component (B) in the catalyst system for homo or copolymerizing ethylenically unsaturated monomers can be any usable acceptor compound for ligand X in the formulas above. These acceptor compounds are commonly lithium, boron or aluminium organometallic compounds such as alkyl or alkyl halide derivatives or salt containing ammonium or carbo cationic part combined with weakly or non-coordinating anions(s). The anions are commonly carbaboranes, fluoro anions of boron or phosphor or tetraalkyl boron complexes. Preferably (B) is an organometal compound, for example organoaluminium compound. Preferable activators are, for example, alumoxane compounds having the formula of  $R-(Al(R)-O)_n-Al(R)_2$ , where n is 1-40, m is 3-40 and R is  $C_1-C_8$  alkyl group. Preferably R is methyl and preferable activator is methylalumoxane (MAO). Illustrative, but not limiting examples for component (B) are methylalumoxane,  $AlClEt_2$ ,  $PbEt_4$ , butyllithium and salts containing  $[CPh_3]^+$  or  $[NHMe_2PH]^+$  cation and  $[PF_6]^-$ ,  $[BF_4]^-$ , nido-carbaborane  $C_2B_9H_{13}^-$ ,  $[B(C_5F_5)]^-$  or  $[BPh_4]^-$  anion.

15

The activator can be applied according to the methods known in the art before polymerization or during the polymerization.

The catalysts according to the invention can be used as homogenous systems or they can be deposited on inorganic or organic carrier. Silica, alumina or polymeric carriers like polyethylene or polystyrene can be used as supports.

The catalysts according to the invention are suitable for homo and copolymerization of all olefinic monomers, for example ethylene, propylene, butene, pentene, hexene, 4-methyl-1-pentene or alike. Further they can be used for polymerization of cycloolefins like norbornene and dienes like butadiene, 1,4-hexadiene or 1,5-hexadiene.

The polymerization can be carried out by slurry, gas phase or solution processes either batchwise or continuously. The polymerization conditions are not critical. Thus polymerization temperatures from 0 to 150 C, preferably 50-110 C, and pressures up to 1000 bar, preferably 5-70 bar can be used.

Typical for the polymers according to invention is very narrow molecular weight distribution, which can be seen from the Table, and a good activity better than that of most Ziegler-Natta catalysts and many metallocene based systems.

## 5 Examples

Syntheses of the compounds, which have been characterized with single crystal X-ray analyses.

### 10 Example 1

2-(Phenylamino)pyridiniumtetrachloro2-(phenylamido)pyridine titanate(IV)  
[PhNHPyH][TiCl<sub>4</sub>(PhNPy)]

15 2-(Phenylamino)pyridine was dissolved to toluene (40 ml). Solution was cooled down to -20 °C. Two molar equivalents of titanium(IV) chloride was added. Temperature of the solution was raised to 40 °C in 45 minutes and kept for one hour. The reaction mixture was filtered. Dark red prismatic crystals suitable for single crystal measurements were obtained at room temperature in 15 hours.

20

### Example 2

Di-μ-chlorodichlorotetrakis[2-(phenylamido)pyridine]-dizirconium(IV)  
[Zr<sub>2</sub>Cl<sub>4</sub>(PhNPy)<sub>4</sub>]

25

Ligand precursor, 2-(phenylamino)pyridine (9.32 g, 54.8 mmol), was suspended to 100 ml of toluene and cooled down to -50°C. Zirconium(IV)chloride (6.20 g, 26.8 mmol) was added to the suspension. Temperature of the continuously stirred suspension was allowed to rise into room temperature in 60 minutes. Mixture which started to turn orange colored  
30 was then refluxed for 45 minutes. The orange solution was separated from oily, amorphous like precipitation and filtered. Large orange crystals were obtained in 2 hours. Yield of the

crystalline homomorphous material was ca. 10%. Mass spectra: (EI)  $m/z$  500 ( $ZrCl_2(PhNPy)_2^+$ ), 463 ( $ZrCl(PhNPy)_2^+$ ).

### Example 3

5

Tetrakis[2-(phenylamido)pyridine]hafnium(IV)  
[Hf(PhNPy)<sub>4</sub>]

2-(Phenylamino)pyridine (1.92 g, 11.3 mmol) was suspended to 70 ml of toluene and cooled down to -50°C. Hafnium(IV) chloride (0.92 g, 2.9 mmol) was added to the vigorously stirred suspension. Solution slowly turned to pale yellow colour when its temperature was allowed rise to room temperature. Solution was heated 2 hours at 90°C. Solution was filtered and pale yellow prismatic crystals were obtained after 20 hours.

### 15 Example 4

Trichlorobis[2-(phenylamidopyridine)]niobium(V)  
[NbCl<sub>3</sub>(PhNPy)<sub>2</sub>]

20 2-Phenylaminopyridine (7.30 g, 42.9 mmol) was suspended to 70 ml of toluene. Niobium(V)chloride (3.72 g, 13.8 mmol) was added to the suspension. Solution which rapidly turned to intense purple was heated 60 minutes at 90 °C, 50 ml of toluene was added and solution was stirred 2 hours at room temperature. Again part of the product was amorphous and insoluble in toluene. Solution was filtered and purple prismatic crystals  
25 were obtained in 10 hours. Yield 2.3 g (31%). Mass spectra: (EI)  $m/z$  536 ( $NbCl_3L_2^+$ ), 367 ( $NbCl_3L^+$ )

### Example 5

30 Bis[2-(benzylamido)pyridine]trichloroniobium(V)  
[NbCl<sub>3</sub>(PyNBz)<sub>2</sub>]

Niobium(V)chloride, 2.36 g (8.73 mmol) and 2-(benzylamino)pyridine 3.22 g (17.3 mmol) were melt at 100 °C for 30 minutes and extracted to toluene (60 ml) with refluxing for 2 hours. Toluene solution was separated from oily purple-black amorphous residue and filtered. Purple crystals where obtained in 15 hours. Estimated yield was 10-15 %.

5

#### Example 6

Trichlorobis[2-(phenylamido)pyridine]tantalum(V)  
[TaCl<sub>3</sub>(PhNPy)<sub>2</sub>]

10

2-Phenylaminopyridine (2.88 g, 16.9 mmol) was suspended to 70 ml of toluene and cooled down to -50 °C. Tantalum(V)chloride (3.03 g, 8.46 mmol) was added to the suspension. Temperature of the suspension was raised in 2 hours up to 90°C. At -10°C solution began to change the colour red. After heating 90 minutes the solution was filtered. Dark red  
15 crystal started to grow in 12 hours. Yield was 2.9 g (54 %). Mass spectra: (EI) m/z 624 (TaCl<sub>3</sub>L<sub>2</sub><sup>+</sup>), 589 (TaCl<sub>2</sub>L<sub>2</sub><sup>+</sup>), 457 (TaCl<sub>3</sub>L<sup>+</sup>)

#### Example 7

20 Trichlorobis(2-phenylamido-6-phenylaminopyridine-N,N')tantalum(V)  
[TaCl<sub>3</sub>(PhNPyNHPh)<sub>2</sub>]

2,6-bis(phenylamino)pyridine (2.14 g, 8.19 mmol), which was prepared as described previously (M. Hamana, M. Yamazaki, Yakugaki Zasshi, 81, 1961, 574), was dissolved to  
25 toluene (40 ml). Solution was cooled down to -20 °C. Tantalum(V) chloride (1.46 g, 4.08 mmol) was added. Temperature of the solution was raised to 40 °C in 45 minutes and kept for one hour. The reaction mixture was filtered. Dark red prismatic crystals suitable for single crystal measurements were obtained at room temperature in 15 hours.

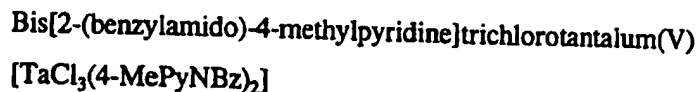
#### 30 Example 8

Bis[2-(benzylamidopyridine)]trichlorotantalum(V)



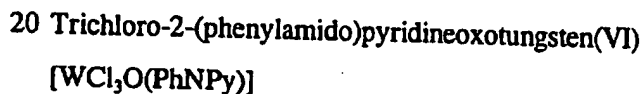
Tantalum(V)chloride, 1.36 g (3.89 mmol) and 2-(benzylamino)pyridine (Mp 95-97 °C), 1.47 g (7.97 mmol) were heated at 100 °C. Melt started to red immediately. After one hour 30 ml of toluene was added, the solution was refluxed for 2 hours, and filtered when hot through Celite. Solution was kept at room temperature and a few drops of n-hexane was added to the solution. Intense red crystalline blocks were obtained in 20 hours. Estimated yield was 50-55 %.

#### 10 Example 9



15 The title compound was prepared analogously to Example 8, but at the temperature of 80 °C.

#### Example 10



2-(Phenylamino)pyridine (4.10 g, 24.1 mmol) and tungsten(V)-oxo-tetrachloride (3.20 g, 9.38 mmol) were heated in toluene (50 ml) suspension for 90 minutes at 80 °C. Solution was then filtered and evaporated to reduced volume (30 ml). Large black crystalline blocks with average size over 1 mm in each dimension were obtained at room temperature in 10 hours.

#### Example 11

30

The compound prepared in Example 8 (Catalyst A) and compound prepared in Example 4 (Catalyst B) as toluene solvates were tested for ethylene polymerization. The catalysts were

weighed to the polymerization reactor, where also methylaluminiumoxane (MAO) was added as cocatalyst so that Al/Ta (Al as MAO) ratio was 2000 mol/mol. The polymerization was carried out in 300 ml toluene. Ethylene pressure was 5.0 bar. The polymerization conditions and results are presented in the following table.

5

10

Table

Cat.	Amount mg	T °C	Time min	Yield g	Activity kgPE/ molTa/h	M <sub>w</sub> g/mol	M <sub>w</sub> /M <sub>n</sub>	T <sub>m</sub> °C
A	10.0	30	20	3.7	800	201200	2.5	137.7
A	5.0	60	7	3.9	5000	93800	2.0	135.4
A	2.0	60	30	2.5	1900	84900	1.9	135.3
A	1.0	60	30	1.0	1500	82800	1.9	134.8
B	5.0	60	7	5.0	7700	90700	1.9	134.8
B	2.0	60	7	2.5	9600	86500	1.9	134.7
B	1.0	60	30	3.2	5800	84500	1.9	135.3
B	1.0	80	7	3.1	23900	66100	1.8	133.9
B	1.0	30	30	0.5	900	115400	1.9	136.3

## Claims

1. A transition metal complex, characterized in that it has a general formula of (I)



where

10      M is a transition metal selected from groups IVb-VIb of The Periodic Chart of the Elements,

RNpy is unsubstituted or substituted amidopyridine derivative,

15      X is a ligand having a valency of 1, and

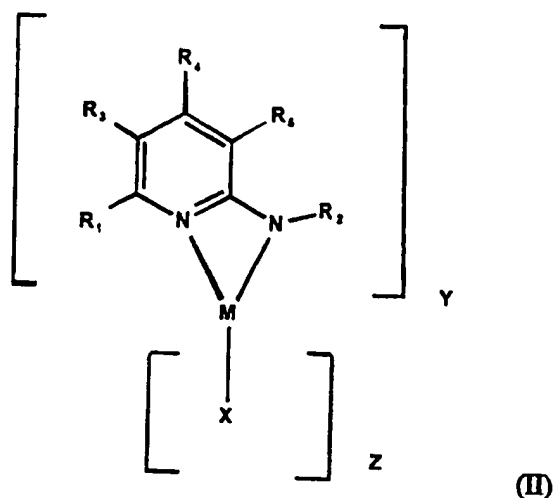
y is 1-4, z is 0-5 and y+z is 3-6.

- 20      2. A complex of claim 1, characterized in that the transition metal M is selected from Ti, Zr, Hf, V, Nb, Ta, Cr, Mo or W.

3. A complex of claims 1 or 2, characterized in that X is halide selected from chloride, bromide, iodine, fluorine or oxy derivative thereof.

- 25      4. A complex according to claims 1-3, characterized in that it has a general formula of (II) :





where

$R_2$  is selected from hydrogen or linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group or cyclic  $C_1$ - $C_7$  alkylene group connected to groups  $R_1$ ,  $R_3$ ,  $R_4$  or  $R_5$  as defined below, or silyl alkyl  $SiRR'R''$  or boron alkyl  $BRR'$  where  $R$ ,  $R'$  and  $R''$  are as defined for  $R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$ .

$R_1$ ,  $R_3$ ,  $R_4$  and  $R_5$  are same or different groups selected from hydrogen, linear, branched or cyclic  $C_1$ - $C_{25}$  alkyl group, or a cyclic  $C_1$ - $C_7$  alkylene group connected to  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$  or  $R_5$ , or substituted main group element (B, C, Si, N, O, P, As, Sb, Pb..) with a substituent as  $R_1$ - $R_5$ ,

$M$  is as defined above,

$X$  groups are independently halide and/or oxo group or alkyl as  $R_2$ , or  $-NRR'$  where  $R$  and  $R'$  are as  $R_2$  defined above, and  $X$  can also act as a bridge between two or more  $M(RNpy)_yX_{z-1}$  units.

$y$  is 1-4,  $z$  is 0-5 and  $y+z$  is 3-6.

20

5. A complex according to claims 1-4, characterized in that  $X$  is halide or alkyl as  $R_2$ , or  $-NRR'$  where  $R$  and  $R'$  are as  $R_2$ .

6. A method for preparing transition metal complexes according to claims 1-5, characterized in that 2-(phenylamido)pyridine or 2-(benzylamido)pyridine is reacted with a halide or halide derivative of a transition metal selected from groups IV-VIb.
- 5 7. A method according to claim 6, characterised in that the transition metal is selected from is Ti, Zr, Hf, V, Nb, Ta, Cr, Mo or W.
8. A method according to claims 6-7, characterized in that the halide is selected from chloride, bromide, iodine, fluorine or oxy derivative thereof.
- 10
9. A method according to claims 6-8, characterized in that the reaction is carried out at a temperature of 50-150 °C.
10. A method according to claims 6-8, characterized in that the reaction is carried out  
15 without solvent in a melt of starting materials.
11. A method according to claim 10, characterized in that the reaction is carried out at a temperature between 50-200 °C.
- 20 12. A catalyst system for homo or copolymerizing ethylenically unsaturated monomers, characterized in that it comprises
- A) a transition metal complex having a general formula (I):
- 25 
$$M(RNpy)_yX_z \quad (I)$$
- where
- M is a transition metal selected from groups IVb-VIb of The Periodic Chart of the Elements,
- 30 RNpy is unsubstituted or substituted amidopyridine derivative,

X is a ligand having a valency of 1, and

y is 1-4, z is 0-5 and y+z is 3-6, and

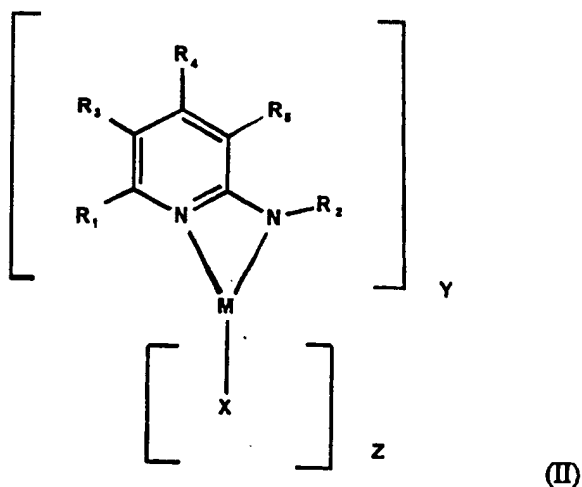
5 (B) an acceptor compound for component X as an activator.

13. A catalyst system according to claim 12, characterized in that the transition metal M is selected from Ti, Zr, Hf, V, Nb, Ta, Cr or W.

10 14. A catalyst system according to claims 12 or 13, characterized in that X is selected from chloride, bromide, iodine, fluoride or oxy derivative thereof.

15. A catalyst system according to claims 12-14, characterized in that component (A) has a general formula (II):

15



where

R<sub>2</sub> is selected from hydrogen or linear, branched or cyclic C<sub>1</sub>-C<sub>25</sub> alkyl group or cyclic C<sub>1</sub>-C<sub>7</sub> group connected to groups R<sub>1</sub>, R<sub>3</sub>, R<sub>4</sub> or R<sub>5</sub> as defined below, or silyl alkyl SiRR'R'''  
 20 or boron alkyl BRR' where R, R' and R'' are as defined for R<sub>1</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub>.

R<sub>1</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>5</sub> are same or different groups selected from hydrogen, linear, branched or cyclic C<sub>1</sub>-C<sub>25</sub> alkyl group, or a cyclic C<sub>1</sub>-C<sub>7</sub> alkylene group connected to R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>

or  $R_3$ , or substituted main group element (B, C, Si, N, O, P, As, Sb, Pb..) with a substituent as  $R_1-R_5$ ,

M is a transition metal as defined above,

5

X groups are independently halide and/or oxo group or alkyl as  $R_2$ , or  $-NRR'$  where R and R' are as  $R_2$  defined above, and X can also act as a bridge between two or more  $M(RNpy)_yX_{z-1}$  units.

10 y is 1-4, z is 0-5 and  $y+z$  is 3-6.

16. A catalyst system according to claim 15, characterized in that X is selected from chloride, bromide, iodine, fluoride or oxy derivative thereof.

15 17. A catalyst system according to claims 12-16, characterized in that component (B) is an organometal compound, preferably organoaluminium compound.

18. A catalyst system according to claim 17, characterized in that component (B) is an alumoxane compound having the formula of  $R-(Al(R)-O)_n-Al(R)_2$  where n is 1-40, m is 3-  
20 40 and R is  $C_1-C_8$  alkyl group.

19. A catalyst system according to claim 18, characterized in that R is a methyl group.

20. A method for homo or copolymerization of ethylenically unsaturated monomer in the  
25 presence of a catalyst system according to claims 12-19.

21. A method according to claim 20, characterized in the catalyst system is used as a homogenous system or supported on inorganic or organic carrier.

30 22. A method according to claim 20-21, characterized in that the monomer is one or more monomer selected from ethylene, propylene, butene, pentene, hexene, 4-methyl-1-pentene, cycloolefins like norbornene and dienes like butadiene, 1,4-hexadiene or 1,5-hexadiene.

23. A method according to claims 20-22, characterized in that is is carried out at polymerization temperatures from 0 to 150 C, preferably 50-110 C, and pressures up to 1000 bar, preferably 5-70 bar according to a slurry, gas phase or solution process.

5

24. Polymers or copolymers of ethylenically unsaturated monomers prepared by any of the methods according to claims 20-23.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00321

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C07F 9/00, C07F 11/00, C07F 7/00, C07F 19/00, C08F 4/64  
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C07F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS-ONLINE

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Inorg. Chem., Volume 35, April 1996, Rhett Kempe et al, "Mononuclear Titanium Complexes That Contain Aminopyridinato Ligands" page 2644 - page 2649 --	1-4
X	Indian J. Chem., Volume 16A, November 1978, K. P. Srivastava et al, "Chelates of Molybdenum Dioxydichloride with Substituted Thioureas & Ureas" page 990 - page 992 --	1-4
X	Nat. Acad. Sci. Letters, Volume 8, No 11, 1985, Kanti Mishra et al, "Characterisation of mixed ligand complexes of Cr(III) with thiocyanate and 2-aminopyridine/8-hydroxy quinoline" page 347 - page 350 --	1-2

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

15 Sept 1997

Date of mailing of the international search report

16 -09- 1997

Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Göran Karlsson  
Telephone No. +46 8 782 25 00

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 97/00321

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Synth. React. Inorg. Met.-Org. Chem., Volume 23, No 7, 1993, R.C. Maurya et al, "Synthesis and characterization of some novel mixed-ligand cyanonitrosyl (Mo(NO) <sub>2</sub> ) <sub>6</sub> complexes of molybdenum with some simple and biologically active organic donors" page 1073 - page 1085 --	1-2
X	Ukrainskii Khimicheskii Zhurnal, Volume 39, No 11, 1973, A. T. Pilipenko et al, "A spectrophotometric study of complexing int the molybdenum-2-benzylaminopyridine-thiocyanate system" page 1169 - page 1173 --	1-2
A	EP 0687693 A1 (BASF AKTIENGESELLSCHAFT), 20 December 1995 (20.12.95) --	1-20
A	US 4169092 A (JOHN W. BAYER), 25 Sept 1979 (25.09.79) -----	1-20

# INTERNATIONAL SEARCH REPORT

Information on patent family members

01/09/97

International application No.

PCT/FI 97/00321

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0687693 A1	20/12/95	DE 4420783 A DE 4428636 A	21/12/95 15/02/96
US 4169092 A	25/09/79	NONE	